LGC-ASTRONAUT INTERFACES DURING LANDING
(Revised for LUMINARY 1D)

by

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Key V37E63E	The ignition algorithm starts immediately after the selection of P63 and computes light-up time and throttle-up time. A prior N69 input is incorporated into the landing site vector at this point. Alarms 1406 and 1412 are possible here if initial conditions are faulty. A 1406 in the ignition algorithm is a POODOO.
V06N61 flashing R1-TG R2-TFI R3-CR	Indicates completion of the ignition algorithm. The time-to-go displayed pertains to throttle-up time, when guidance commences. TFI counts down toward ignition. Crossrange tells how far the present site - with N69 incorporated if there was one - lies from the LM orbital plane, to the nearest tenth of a nautical mile.
V50N25 flashing R1-00014	Please perform IMU fine align. ENTER to bypass. If you accidentally PROCEED the easiest way to get back to the main-line program is to reselect P63.
V50N18 flashing Ball angles	This display appears both at the start (PROCEED) and at the end (ENTER) of the R60 manoeuvre to the initial burn attitude.
Possible flashing V50N25 R1-00500	This comes up if the LGC is not receiving the landing radar antenna position 1 discrete. Either the antenna is not in position 1 or the LR circuit breaker is open. Because of the circuit breaker Apollo 11 saw this display. PROCEED causes the discrete to be checked again; ENTER bypasses.

Possible flashing V50N25 R1-00203	This appears if GUID CONT is not in PGNS, or THR CONT is not in AUTO, or PGNS MODE CONTROL is not in AUTO. On PROCEED the discretes are checked again; ENTER bypasses.
Possible alarm	If integration cannot be completed in time for turning on average-G at TIG-30, ignition and throttle-up are slipped and alarm 1703 is issued. Throttle-up must not be slipped in P63, so unless the ignition slip is known to be small and the engine can be throttled up manually on time, the landing should not be continued.
V06N62 R1-VI R2-TFI R3-DELTAVM	Count-down to ignition. VI is the inertial velocity at TIG-30. DELTAVM will be zero until ullage begins. This display will blank itself at TIG-35 and will reappear 5 seconds later when average-G is turned on.
V99N62 flashing	PROCEED to authorize ignition. A late PROCEED here slips ignition but not throttle-up, unless it comes after throttle-up, when of course it is not desirable.
V06N63 R1-VI R2-HDOT R3-H	The appearance of this display indicates that the engine has been commanded on and that aborts are permitted, until the selection of P68, merely by pushing ABORT or ABORT STAGE.

Possible flashing
V97N63

This appears if the LGC thinks the DPS has failed. On PROCEED the delta-V monitor is reset and the engine is given another chance to live up to the delta-V threshold - which in P63 corresponds to roughly 600 pounds thrust. ENTER would cause the ignition sequence to be repeated from the TIG-5 point. Flashing V97 also comes up if the engine fails during the burn. In this case the descent should be ended with an ABORT STAGE. If the engine is on and V97 appears, a PIPA may have failed.

Key V57E

After the LM yaws to windows-up, either automatically at 30,000 feet or manually before then, the landing radar should be started.

V06N68 flashing
R1-Range
R2-TG
R3-DELTAH

When DELTAH, the difference between LR measured and LGC computed altitude, appears reasonable, answer this display with a PROCEED to enable updating of the state vector V34E terminates V57 and restores the previous display.

V50N68 flashing

This display will show DELTAH converging on zero as LR data is incorporated. When you get tired of watching it, PROCEED to get back V06N63. ENTER causes updates to be inhibited again and restores the V06N68 display. After a PROCEED on this display, use V58 to inhibit landing radar updates.

Possible overload alarms

Alarms 1201 and 1202, accompanied by software restarts, will occur if the LGC is overloaded, either because there is too much program activity, or too little processor time. In Apollo 11, rendezvous radar hardware snatched 15% of LGC time. The frequency of these alarms indicates the seriousness of the overload. Apollo 11 suffered 3 within 40 seconds in P64. These alarms should alert you to the possibility of further bad behavior, such as attitude oscillations, which may make it impossible to continue the landing.

Possible guidance alarms

Alarms 1406 and 1410 may be issued by the guidance equations in P63 and P64. Alarm 1406 indicates that the time-to-go computation is failing; 1410 indicates an overflow in the guidance equations. When either alarm is issued vehicle rates are stopped and no attitude or throttle commands are sent out. If these alarms persist P63 or P64 should be terminated in favor of P66 if possible, or P70 or P71.

V06N64 flashing
R1-TR/LPD
R2-HDOT
R3-H

This display appears at high-gate when P64 begins. PROCEED enables the ACA for use as a landing site redesignator. (However, whenever the MODE is attitude-hold the ACA functions instead as an attitude controller.) If you never want to redesignate you need not respond to this display at all.

To enter P66

The ROD mode is entered either automatically from P64 at 100 feet or manually from P63 or P64 by putting the MODE CONTROL in attitude hold and clicking the ROD switch. While in P66, the crew can select either P66 AUTO or P66 MANUAL via the MODE CONTROL switch. In both modes, vertical velocity is controlled by the ROD switch in one fps increments. In P66 AUTO, the LGC controls LM attitude and nulls the horiz. velocities.

V06N60 flashing

R1 - FORVEL

R2 - HDOT

R3 - H

P66 posts this display. PROCEED (or ENTER) causes autopilot attitude errors to be zeroed. On touchdown, PROCEEDING and switching the ENGINE ARM to OFF will inhibit jet firings.

Key V37E68E	Select P68 when you are sure an immediate ABORT STAGE from the surface is not necessary.
V06N43 flashing R1-LAT R2-LONG R3-ALT	This display of landing site position is computed from the LGC's state vector. Since state vector errors are compensated for by biasing the landing site vector instead of corrected, this display will be off by the amount of site bias plus the uncompensated LGC navigation error. This error in the LGC's idea of where it is will show up again in the Crossrange display (N74) in P12. If the desired site (which is in the CSM's orbital plane) was actually achieved, and an ascent using P12 is necessary before the ground can compute a better value, Crossrange should be loaded with zero.
V37 flashing	Select another program.

SPECIAL TOPICS

On Call Displays

Nouns 60, 62, 63, 64, 68 & 92 can be called between TIG -30 and the selection of P68 without displaying any misleading information: anything that is changing is good. Not all contain anything useful. N62 contains DELTAVM, a cumbersome measure of fuel expenditure. N64 has the LPD angle and might enable you to identify the site before high-gate. The LPD display is accurate if it is within the visible range; nearer 90^{o} it breaks down. N68 has three new items, slant-range to the site, guidance time-to-go, and in R3 DELTAH which is used to decide when to enable landing radar updates. N92 contains

R1 - THR CMD

R2 - HDOT

R3 - H

THRCMD is the percent throttle desired by the LGC, based on the DPS rated thrust of 10500 pounds. THRCMD was put in when P67 was eliminated to assist the pilot in flying the throttle manually in P63, P64 or P66. During most of the braking phase THRCMD will be greater than 100% since the guidance desires more thrust than the engine can deliver.

Redesignator

Redesignations are made in P64 after a PROCEED to flashing V06N64 by deflecting the rotational hand controller in the direction of the desired displacement of the site. E. g. a - pitch deflection moves the site downrange. Vehicle roll and yaw may give lateral redesignations a downrange or uprange component, and give range redesignations a lateral component. Redesignations are counted when the stick returns to detent, to prevent a large unintentional displacement of the site in the event of a rapid series of restarts. The stick must not be allowed to snap back across the detent when it is released, or the redesignation might be counted in the wrong direction.

Throttle

When THR CONT is in AUTO the manual throttle defines the minimum throttle setting possible. The manual throttle must not be used to command a throttle setting higher than guidance desires. To compensate for excessive upward thrust the guidance equations may command the vehicle to thrust downwards. If you have to throttle-up manually (as in the case of a small-slip 1703 alarm) remember to return the manual throttle to minimum after the guidance equations begin. If the throttle is prevented from responding to throttle-down within about 40 seconds, the LM will pitch approximately 180^{o}.

P67, the mode in which the pilot flies both throttle and attitude manually, was eliminated for LUMINARY 1C. Putting the throttle control switch in MANUAL no longer causes a switch in major mode. P67, however, is only gone in name: any of the other programs with mode in attitude-hold and throttle in manual is equivalent - and equally difficult to fly. Warning: be careful when flying with mode in auto and throttle in manual not to command more thrust than the LGC desires, as this might cause the guidance equations to ask the vehicle to thrust downwards to compensate. For the same reason be careful when switching mode from attitude-hold to auto when the throttle has been under manual control.

Noun 69

Noun 69 lets one modify the landing site at any time during the landing. Its three components are

Landing site change along ZSM - downrange
Landing site change along YSM - crossrange
Landing site change along XSM - altitude

where ZSM etc. are the axes of the platform coordinate frame and the epithets "downrange" etc. assume the nominal landing alignment of the platform. Crossrange is positive to the right, negative to the left. All components are scaled in whole feet. 28 keystrokes are necessary to

modify all components, e.g.

V 25 N 69 E +20000 E +00500 E +00250 E.

14 keystrokes suffice to change any one component, e.g.

V 23 N 69 E +00250 E.

Similarly V21 can be used to load the first component only, and V22 to load the second.

N69 can be incorporated in the ignition algorithm (at the very beginning of P63) or during guidance, which begins at throttle-up time.

If N69 is loaded:	the site will be changed:
before the selection of P63	in the ignition algorithm, and ignition time will be adjusted accordingly.
between the ignition algorithm and the start of guidance at throttle-up time	at throttle-up time. Since it is too late to modify light-up time, N69 inputs from this period on must be moderate in magnitude. A small attitude transient may be observed at throttle-up time.
after throttle-up	immediately. A small transient may be observe

If N69 is never loaded the site is never changed, because its registers were pad-loaded zero. If N69 is reloaded before a previous N69 has been incorporated, the previous values will be overwritten. This will occur if there is more than one N69 before the start of P63, or if there is more than one between the flashing V06N61 and throttle-up time.

If for any reason P63 is reselected the landing site vector LAND (platform coordinates) which was modified by N69 is reinitialized from the vector RLS (selenographic coordinates) which was not changed. Thus if P63 is reselected N69 inputs must be repeated.

P66

P65 has been eliminated and two P66 modes, Auto and Manual, are now in existence. P66 Manual is exactly equivalent (to the old P66) and is called in the same way by switching the MODE SELECT switch to Attitude Hold and clicking the ROD switch.

P66 Auto is entered one of two ways, automatically at low gate as P65 was, or from P66 Manual by switching from Attitude Hold to Auto. In addition to controlling vertical rate via the ROD switch, P66 Auto will control the vehicle attitude and automatically null all horiz. velocities.

The P66 mode may be changed at will by use of the MODE SELECT switch, but P63 or P64 cannot be reentered from either P66 mode.